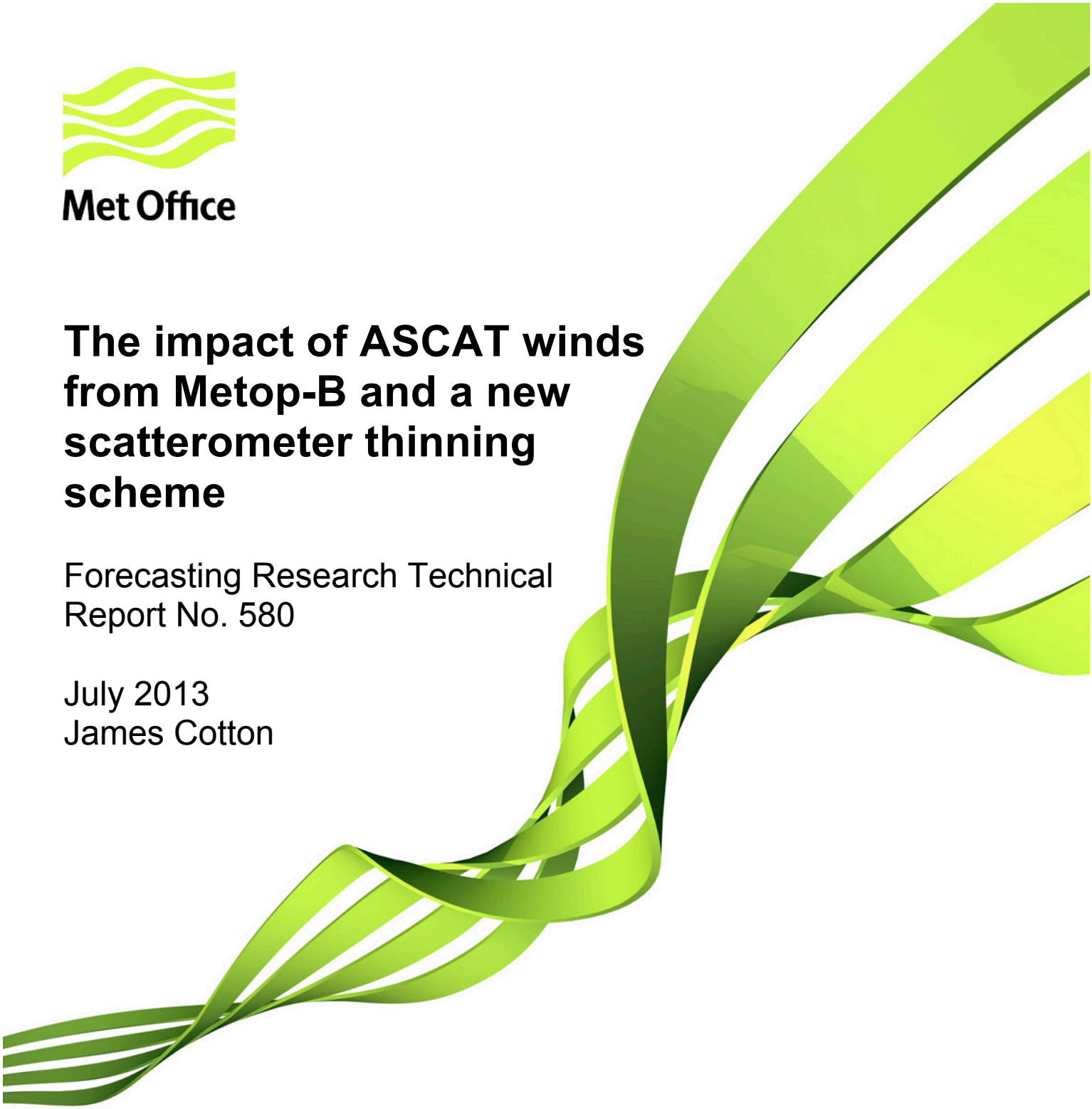

The impact of ASCAT winds from Metop-B and a new scatterometer thinning scheme

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James Cotton

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Abstract

Ocean-surface wind vectors from the ASCAT instrument on Metop-B are compared with short range forecasts of 10m winds from the Met Office global model. The scatterometer winds from ASCAT-B are found to be very similar to that of ASCAT-A with only small differences observed in speed bias. Using the current 'operational' assimilation scheme, the number of ASCAT-B observations used is half that of ASCAT-A. A new 'individual' thinning scheme is proposed to make better use of the additional data from dual Metop-A/B operations.

Without Metop-B, the individual thinning scheme has a small positive impact on forecasts, primarily due to the assimilation of more OSCAT data in regions where the swath overlaps with ASCAT-A.

The impact of assimilating ASCAT-B winds has been investigated using the two different spatial thinning schemes: operational and individual. Despite large differences in the number of observations uses, both schemes show a similar, small positive impact on NWP index scores. Results suggest that ASCAT-B mostly provides additional impact when we add observations into areas not already observed by ASCAT-A. An outage of Oceansat-2 data during the trial period shows that the addition of ASCAT-B leads to a more resilient system and the benefit of a second ASCAT is greatest when we lose another important instrument such as OSCAT.

Ocean surface wind vectors from ASCAT on Metop-B have been assimilated in the Met Office global model from 30 April 2013

1 Introduction

Metop-B was launched on 17 September 2012 and is the second in a series of three satellites to carry the Advanced Scatterometer (ASCAT) instrument. ASCAT is able to provide information on the ocean-surface wind speed and direction and operates at a frequency in C band (5.255 GHz) giving the instrument a near all-weather capability. Surface wind vectors from ASCAT on Metop-A (hereafter referred to as ASCAT-A) have been operationally assimilated into the Met Office global model since 17 November 2007, providing a positive impact on forecasts and analyses (see Keogh and Candy, 2008). A recent study by Joo et al. (2012) used the adjoint-based Forecast Sensitivity to Observations (FSO) method to examine the total impact of all Metop-A observations on the reduction of 24-hour forecast error. Metop-A data were found to contribute 25% of the total observation impact from all assimilated observations (the largest impact of any individual platform), with ASCAT-A providing 14% of the total Metop-A impact.

A Metop-B ASCAT (hereafter ASCAT-B) 25-km wind product has been available for evaluation since 15 November 2012 with an 'in development' status. The data have been stored and routinely monitored at the Met Office since 21 November 2012. ASCAT backscatter data are first processed to level 1 by EUMETSAT and then to a level 2B wind vector product by the Ocean and Sea Ice Satellite Application Facility (OSI SAF) at KNMI. Metop-B was declared operational on 24 April 2013.

The first half of this report examines the quality of wind vectors from ASCAT-B and forms the evidence base for the swift inclusion of the data into Met Office operations. The second half of the report verifies the forecast impact of ASCAT-B and considers whether we can extract more benefit from the parallel ASCAT-A/B operations through changes to the assimilation. In section 5 we examine the current operational scatterometer thinning scheme and consider alternative options for use with ASCAT-B. Section 6 presents assimilation trial results comparing the impact of ASCAT-B under the different thinning schemes.

2 Data coverage

Metop-A and Metop-B are flying in the same 'mid-morning' orbital plane, with a local equator crossing time (LECT) of 0930 (descending), but are separated in time by half an orbit (48.9 mins).

At present, scatterometer wind (Scatwind) observations are spatially thinned to a distance of 80-km in the global model, with just one wind per grid-box in each 6-hour assimilation cycle. In overlap regions winds are prioritised based on a pre-assigned thinning score.

Figure 1 shows an example of Scatwind data coverage when ASCAT-B is added to the current observing system. In this example we have assigned ASCAT-B a lower thinning score than ASCAT-A, such that in order of decreasing priority the scores are: ASCAT-A, ASCAT-B, OSCAT, WindSat. The swaths of ASCAT-A and ASCAT-B overlap significantly in the tropics with the right-swath of B almost overlapping the left swath of A and vice-versa. The number of ASCAT-A observations however remains unchanged since it takes priority over all others. There is some redundancy in the coverage of OSCAT resulting from the addition of ASCAT-B. Overall, there is improved coverage from ASCAT-B in the mid latitudes but only a fairly modest increase of 14% in the number of used Scatwind observations (Table 1).

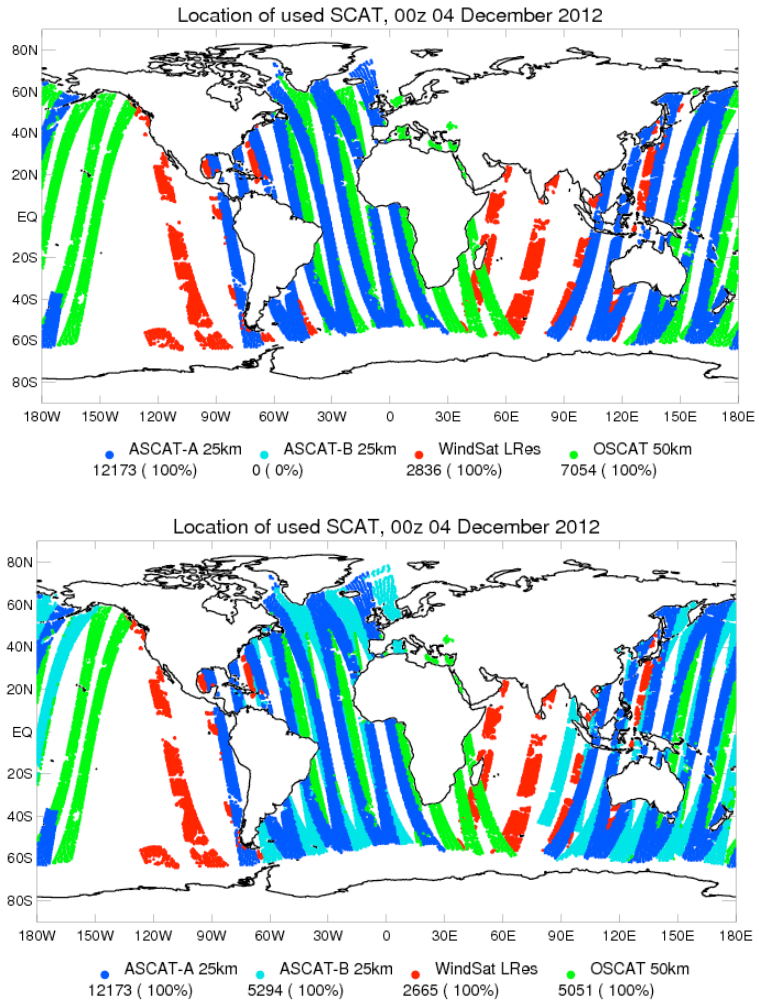

Figure 1. Data coverage plots for a 6-hour period centred at 0 UTC 4 December 2012: control run as per operations (top) and with ASCAT-B data added to the system (bottom).

	Control [C]	Test [T]	[T]-[C]
ASCAT-A	12,173	12,173	0
ASCAT-B	0	5,294	+5,294
OSCAT	7,054	5,051	-2,003
WindSat	2,836	2,665	-171
Total	22,063	25,183	+3,120

Table 1. Impact of ASCAT-B on the number of used Scatwind observations for a single cycle centred at 0 UTC 4 December 2012.

3 Comparison with model background fields

In this section we compare ASCAT-B and ASCAT-A with 10m winds from the Met Office global model background for data in December 2012. The ASCAT-B winds considered here utilise a L1B product with preliminary calibration based on a cross-calibration with ASCAT-A using common rainforest region (backscatter within 0.1dB on all beams). Minor adjustments have since been made to the calibration following the results of the transponder campaign.

In this comparison ASCAT-B observations have been quality controlled in exactly the same way as for ASCAT-A, but with no wind speed bias correction applied to either instrument. Data are rejected if any of the following are true:

- Less than 2 winds have been retrieved
- The retrieved wind speed is outside range 2-25 m/s
- SST less than 273.15 K according to OSTIA
- Land or sea ice is present according to the model.
- Observations south of 72°S (avoids permanent ice sheets not part of the sea ice analysis).
- Maximum likelihood estimate (MLE) quality control: rank1 MLE values are normalised by speed and observations are rejected if MLEnorm > 7 or MLEnorm < -20
- If any of the following bits are set in the supplied wind vector cell (WVC) Quality Flag (see ASCAT Product User Manual):
    - bit 7 - data redundant
    - bit 13 - wind inversion not successful
    - bit 14 - part of WVC over ice
    - bit 15 - part of WVC over land
    - bit 18 - product monitoring flag
    - bit 20 - beam Kp noise exceeds threshold

As scatterometers provide ambiguous wind solutions we select the wind alias closest to the background as being the 'chosen' wind. A breakdown of observed minus background (O-B) statistics as a function of wind speed is given in Figure 2 and Table 2. For observations in the range 2-15 m/s the mean wind speed bias is very similar and both ASCAT-A and ASCAT-B exhibit a small positive bias with respect to the model. For wind speeds greater than 15 m/s, ASCAT-B is slightly faster and as a result has more of a positive bias at higher wind speeds. However, above 20 m/s where the differences are most noticeable there are very few winds observed in each speed bin. The overall wind quality of the two instruments is very comparable, with root mean square vector differences (RMSVD) nearly identical across all wind speeds. Wind component standard deviations for ASCAT-B are 1.27 m/s for zonal (u) and 1.41 m/s for meridional (v), well within OSI SAF specifications (2 m/s error in u/v).

The time series plots in Figure 3 show that the speed bias is stable throughout the month for both ASCAT-B and ASCAT-A. The mean speed bias is fractionally higher for ASCAT-B but RMSVD values are near identical.

It is important to remember that both the scatterometer and the model forecast contribute towards the differences seen in the O-B plots; neither can be assumed to be 'truth'. The model winds used in these comparisons represent the 'real' 10m wind whereas the observations are tuned to be equivalent-neutral 10m winds. Over the global ocean, the average difference between neutral and stability dependent 10m winds is around +0.2 m/s so a small residual bias of around this magnitude is to be expected for ASCAT-A/B prior to any bias correction. A neutral wind observation operator is currently in development to account for this difference. Also note that the background fields compared with ASCAT-B contain information resulting from the assimilation of ASCAT-A.

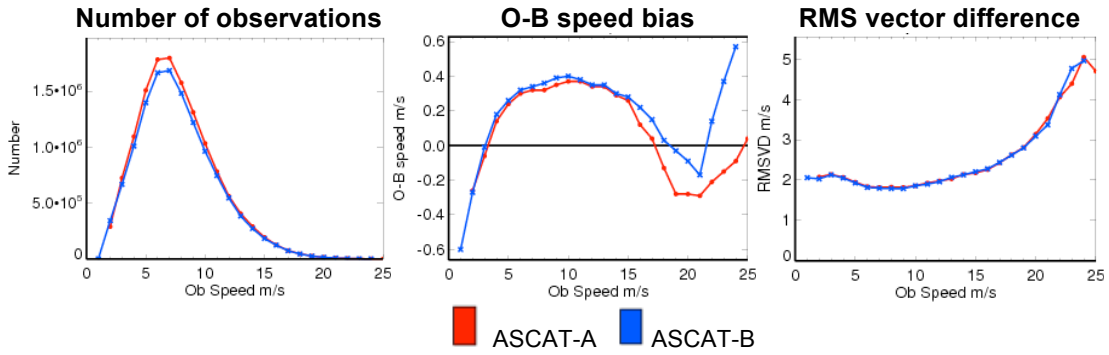

Figure 2. The number of observations (left), mean wind speed bias (middle) and root mean square vector difference (right) versus the Met Office global model background as a function of

the observed wind speed. Statistics are shown for 25-km ASCAT-A (red) and ASCAT-B (blue) for data in December 2012.

Wind Speed Range	Number		Mean O-B Wind Speed m/s		SD O-B Wind Speed m/s		SD O-B Wind Direction °	
	ASCAT-A	ASCAT-B	ASCAT-A	ASCAT-B	ASCAT-A	ASCAT-B	ASCAT-A	ASCAT-B
2-5 m/s	2107851	2020187	0.02	0.04	1.18	1.16	28.5	29.0
5-10 m/s	7980018	7454525	0.31	0.33	1.08	1.07	13.1	13.0
10-15 m/s	3076075	2910479	0.35	0.37	1.14	1.14	8.1	8.0
15-20 m/s	467887	450433	0.12	0.20	1.42	1.44	6.8	6.9
20-25 m/s	29369	27163	-0.26	-0.04	2.15	2.07	8.2	8.2

Table 2. O-B statistics for different wind speed regimes for ASCAT-A and ASCAT-B during December 2012.

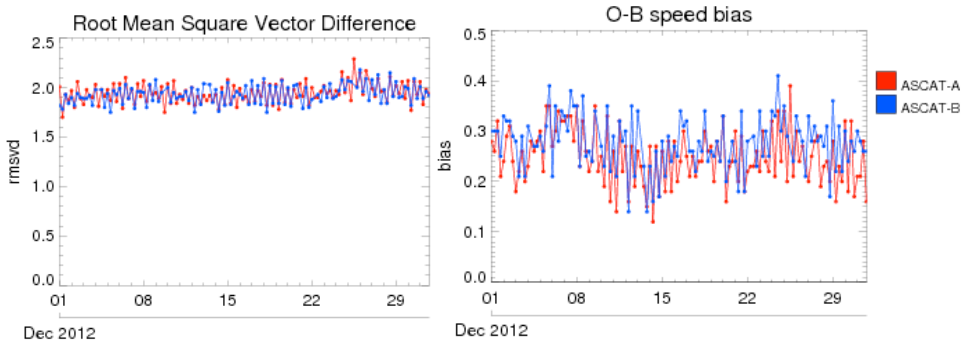

Figure 3. Time series plots of RMSVD (left) and O-B speed bias (left) for ASCAT-A and ASCAT-B data in December 2012. Statistics are versus the Met Office global model background.

The geographical distribution of the ASCAT-B speed and direction bias is the same as ASCAT-A (see Figure 4). The largest departures are observed in the tropics near the location of the Inter-tropical Convergence Zone (ITCZ). The only obvious difference between the two instruments is that a greater number of ASCAT-B observations are rejected (or not retrieved) around the sea ice edge in the South Atlantic Ocean.

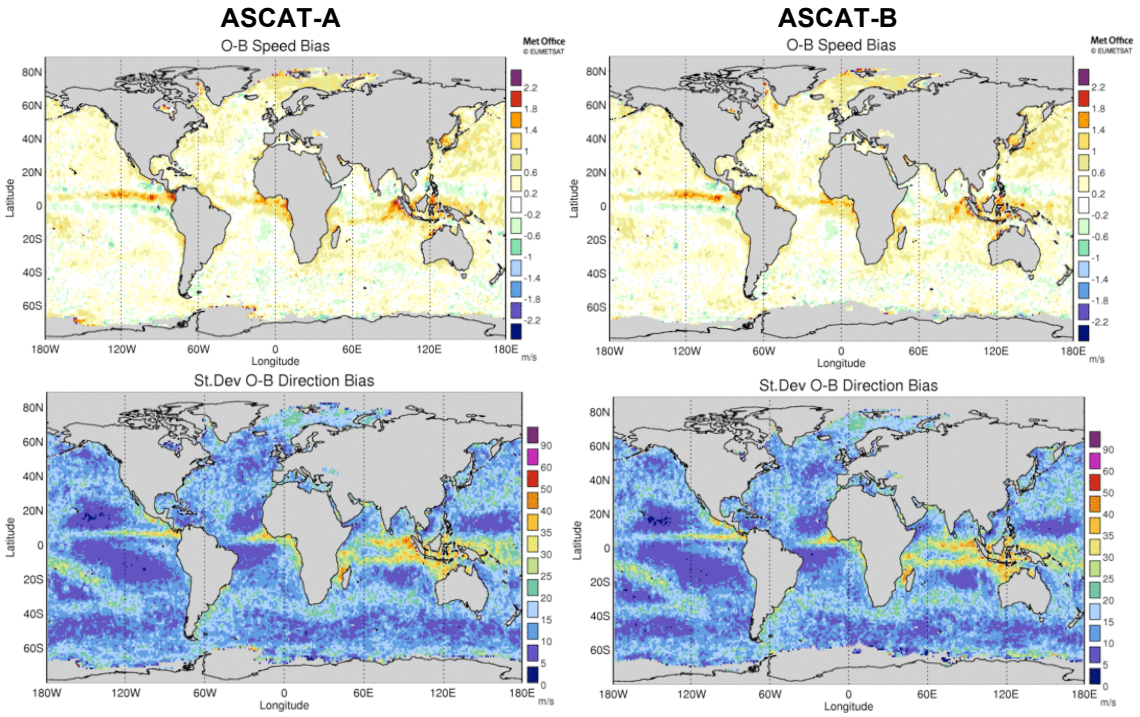

Figure 4. Map plots of mean O-B wind speed bias (top) and standard deviation wind direction bias (bottom) for ASCAT-A (left) and ASCAT-B (right) in December 2012. Statistics are versus the Met Office global model background.

The ASCAT viewing geometry is composed of six vertically polarised (VV) radar beams which trace out 2x550 km wide swaths separated by a 670 km gap. For ASCAT wind products at 25-km spatial sampling, data are organised into rows of 42 wind vector cells (WVCs), numbered from outer-left to outer-right swath (21 in each swath). A comparison of the retrieved winds as a function of WVC number is given in Figure 5. ASCAT-B has a slightly higher positive speed bias (by ~0.05 m/s) for the right-hand swath but generally the O-B speed bias distribution looks very similar. In general, the largest RMS vector differences are found for the cells nearest nadir as the change in sigma-0 with varying wind direction is smaller at higher incidence angles. The ASCAT-B RMS values are in fact slightly lower than for ASCAT-A in the centre of the swath.

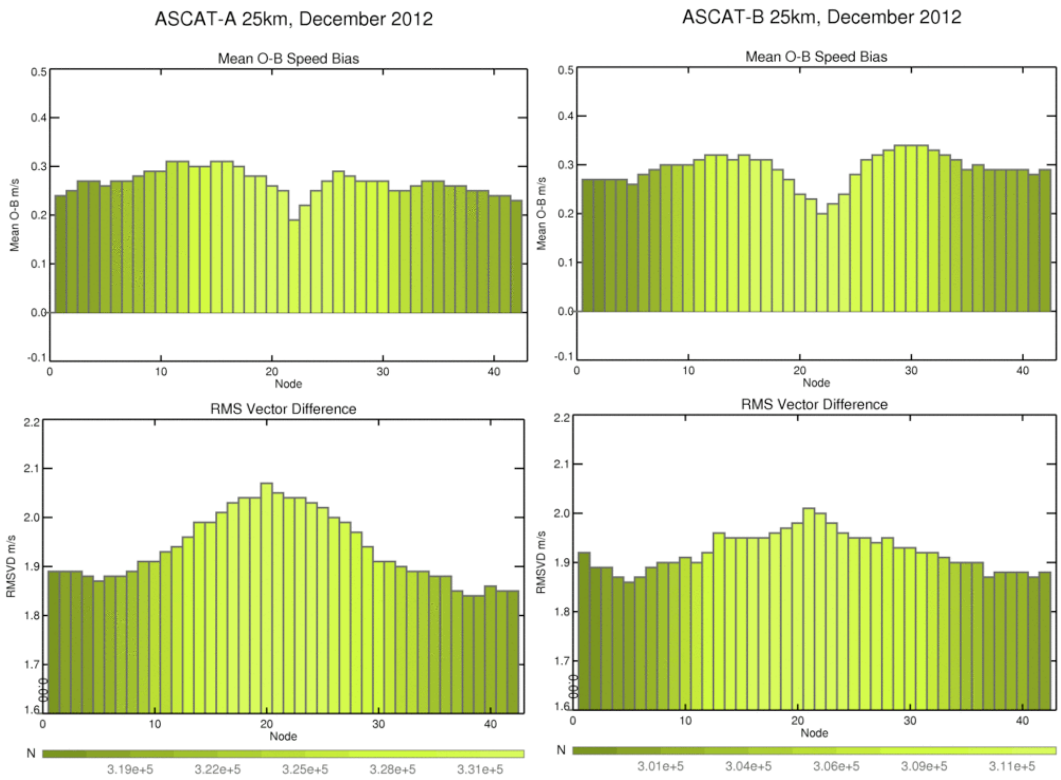

Figure 5. O-B statistics for ASCAT-A (left) and ASCAT-B (right) as a function of swath position during December 2012. Mean speed bias (top) and RMS vector difference (bottom). The colour shading denotes the number of observations in each WVC.

4 Monitoring summary

Monitoring results for December 2012 show that the ASCAT-B wind vectors are already of a very high quality. The O-B statistics are very similar to that of ASCAT-A with only small differences in speed bias observed above 15 m/s. Due to the orbital overlap with ASCAT-A the number of additional observations after thinning is fairly modest in the current assimilation scheme. On the basis of the positive benefit seen from ASCAT-A and the monitoring results presented here, it was recommended that ASCAT-B be included in Parallel Suite 32 (PS32), without the need for prior assimilation trials. As a minimum, ASCAT-B will provide increased resilience to the Scatwind observing system in case of a problem with Metop-A.

ASCAT-B configuration for initial operational implementation:

- Observation Processing System (OPS) quality control the same as for ASCAT-A (see start of section 3)
- 2 m/s observation error (u/v) such that all ASCAT-A and ASCAT-B observations are given the same weight in forming the analysis

- For each observation, equal *a-priori* probabilities are assigned to each of the wind aliases: the same as for ASCAT-A. For example, if an ASCAT-B observation has two wind aliases, then each alias has prior probability of 0.5.
- ASCAT-B observations assigned a thinning score of 20: ranked behind ASCAT-A, but ahead of OSCAT and WindSat.

ASCAT-B winds were included in the Met Office global model at PS32 and became operational on 30 April 2013.

5 Thinning schemes

The current method used to thin scatterometer observations is based on thinning all the data together in one spatial thinning round (hereafter referred to as the 'operational thinning' scheme)

- Thinning distance 80-km (global)
- Assigned thinning scores: platform (score)
    1. ASCAT-A (30)
    2. ASCAT-B (20)
    3. OSCAT (10)
    4. WindSat (7)
- Final chosen wind is closest to the centre of thinning box
- Only one wind assimilated/box in 6 hour assimilation cycle

In this scheme, observations are thinned to one scatterometer wind per 80x80 km thinning box. Where data are present from only one platform we simply select the observation closest to the centre of the box. Where multiple platforms are present (overlap regions) we retain only the observations with highest assigned thinning score and then select the observation closest to the centre of the box. An example of this is shown in Figure 6. ASCAT-A is used in preference to all other observations and 12155 observations are used after thinning to 80-km. Equatorward of 40°N/S, ASCAT-B has significant overlap with ASCAT-A and only 6382 ASCAT-B observations remain after thinning: 50% of that of ASCAT-A. OSCAT at 1200 LECT (descending) is able to fill in some of the gaps between ASCAT swaths but loses out in the mid-latitudes. WindSat at 0630 LECT has slightly less overlap.

To better exploit data from parallel ASCAT-A/B operations we consider the implementation of separate spatial thinning rounds for each instrument (hereafter

referred to as the ‘individual thinning’ scheme). For Metop-A and Metop-B this means that in the overlap region we assimilate data from ASCAT-A, followed by data from ASCAT-B for the same patch of ocean 50 minutes later. This would give information on the wind tendency as observed by ASCAT. An example of this is shown in Figure 7. Each platform is thinned to 80-km with no thinning between platforms. For ASCAT-A there is no impact, but for ASCAT-B we now use 13527 observations: slightly more than ASCAT-A, but in general these two platforms are used equally. OSCAT use increases by 70% to 12220 and WindSat increases by nearly 50%. Overall there is a 50% increase in total Scatwind observations from 28785 to 42427.

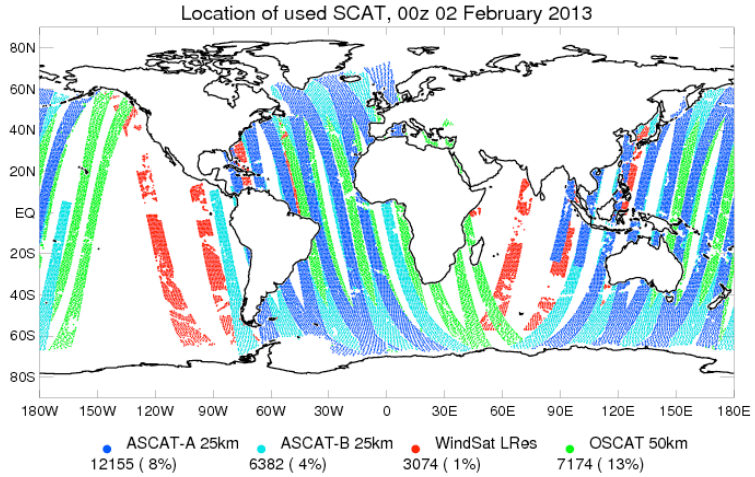

Figure 6. Data coverage plot for a 6-hour period centred at 0 UTC 2 February 2013. Current thinning scheme as used in PS32. The percentage of observations used for each instrument is shown in brackets. ASCAT-B usage is around 50% of that of ASCAT-A.

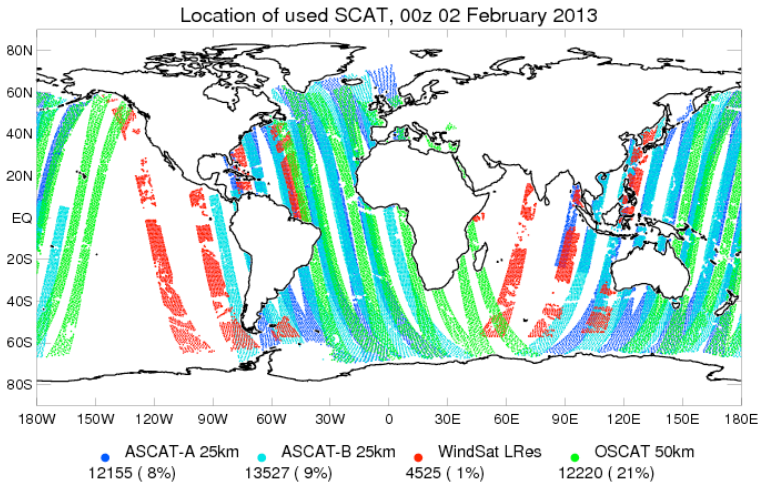

Figure 7. As Figure 6 but using separate spatial thinning rounds for each instrument. Observations are over-plotted in the overlap regions.

6 Assimilation trials

In this section we present assimilation trial results comparing the impact of ASCAT-A and ASCAT-B on Met Office forecasts and analyses under the different thinning schemes. The trial period chosen was from 1 February 2013 to 25 March 2013, giving 52 days of verification. The experiment configurations are based on Parallel Suite 31 (PS31) which was implemented as the operational suite from January 2013. To save on computational resources the horizontal forecast resolution was reduced to N320 (from N512) which equates to approximately 40 km at mid-latitudes. The vertical grid dimensions were as per operations with 70 vertical levels reaching a model lid at around 80 km. Global analyses were created four times each day at 0, 6, 12 and 18 UTC using 4D-Var and forecasts were run at 0 and 12 UTC out to a lead time of six days.

A control suite (sjcna) was run with data-use closely matching that in operations at the time. However all types of Metop-B data were rejected. The current operational Scatwind thinning scheme was used.

From the reference suite, several experiments were performed as outlined in Table 3. Using the same operational thinning scheme, experiment sjcne was designed to gauge the impact of denying ASCAT-A data, whilst experiment sjcnc gave the impact of adding ASCAT-B on top of ASCAT-A. Experiment sjcnf was modified from the control to instead make use of the individual thinning scheme and sjcnd then gave the impact of adding ASCAT-B on top of ASCAT-A under the new scheme. A schematic representation of the experiment setup is given in the appendix.

Scatwind thinning	Experiment	Details	NWP Index score (ref)
Operational thinning	Control sjcna	Reference suite • No Metop-B • Scatwind: ASCAT-A, OSCAT, WindSat • Operational thinning scheme	-
	sjcne	As sjcna but • reject ASCAT-A winds	-0.22 (sjcna)
	sjcnc	As sjcna but • add ASCAT-B	+0.13 (sjcna)
Individual thinning	sjcnf	As sjcna but • Individual thinning scheme	+0.12 (sjcna)
	sjcnd	As sjcnf but • Add ASCAT-B	+0.17 (sjcnf)

Table 3. Impact trial configurations. Met Office NWP Index scores verified against observations are also shown for each experiment relative to the reference suite in parentheses.

6.1 Impact on forecasts: NWP index

The impact on global model forecasts is verified by comparing forecast variables (e.g. wind, PMSL, geopotential height) with quality controlled observations valid at the same time and calculating the difference in RMS between the trial and control values. An important metric for accessing forecast impact at the Met Office is the so-called global NWP index which is a weighted skill score combining improvements in forecast skill for a subset of atmospheric parameters. Note that the formulation of the NWP index was substantially updated in 2012 (more equal weight across lead times and revised set of observations used). The overall change in NWP index score for each experiment can be seen in Table 3.

a) individual thinning scheme

We first consider the impact of the individual thinning scheme alone by verifying experiment sjcnf against the control sjcna, with both suites having no Metop-B data. The change in forecast RMS (trial – control) for the NWP index parameters is given in Figure 8. The statistics are separated by latitude band and forecast lead time, with negative RMS differences representing an improvement in forecast accuracy as a result of the new thinning scheme. The NWP index shows a neutral-to-small positive impact of +0.12 points and Figure 8 shows the most notable changes in RMS are observed in the southern hemisphere. Generally small improvements are seen in southern hemisphere 500 hPa geopotential height and 250 hPa winds. The remaining parameters that make up the NWP index look rather neutral. The NWP index of course only represents a small subset of all available forecast parameters (see right plot of Figure 8) and outside of these metrics further small but consistent improvements are observed for:

- Low level (850/700 hPa) temperature scores in the tropics
- Mid-high level (500/250/100 hPa) temperature scores in the southern hemisphere
- Geopotential height scores (850/700/500/250 hPa) in the southern hemisphere
- Long-range wind scores (250-700 hPa) in the southern hemisphere

No consistent signs of any degradation to forecast parameters are observed.

The small positive impact from the new thinning scheme shows that we can derive some benefit from assimilating more OSCAT and WindSat observations in areas already observed by ASCAT-A. In this experiment the benefit is largely constrained in the southern hemisphere. An extra 660,000 OSCAT and 210,000 WindSat winds were assimilated over the course of the trial and the map plots in Figure 9 show most data were added in the mid-latitudes. Around 50% of the additional data are located in the southern hemisphere extra-tropics: the region where we see most impact. The maps

also demonstrate how the orbits of OSCAT and WindSat are complimentary and add observations in different regions.

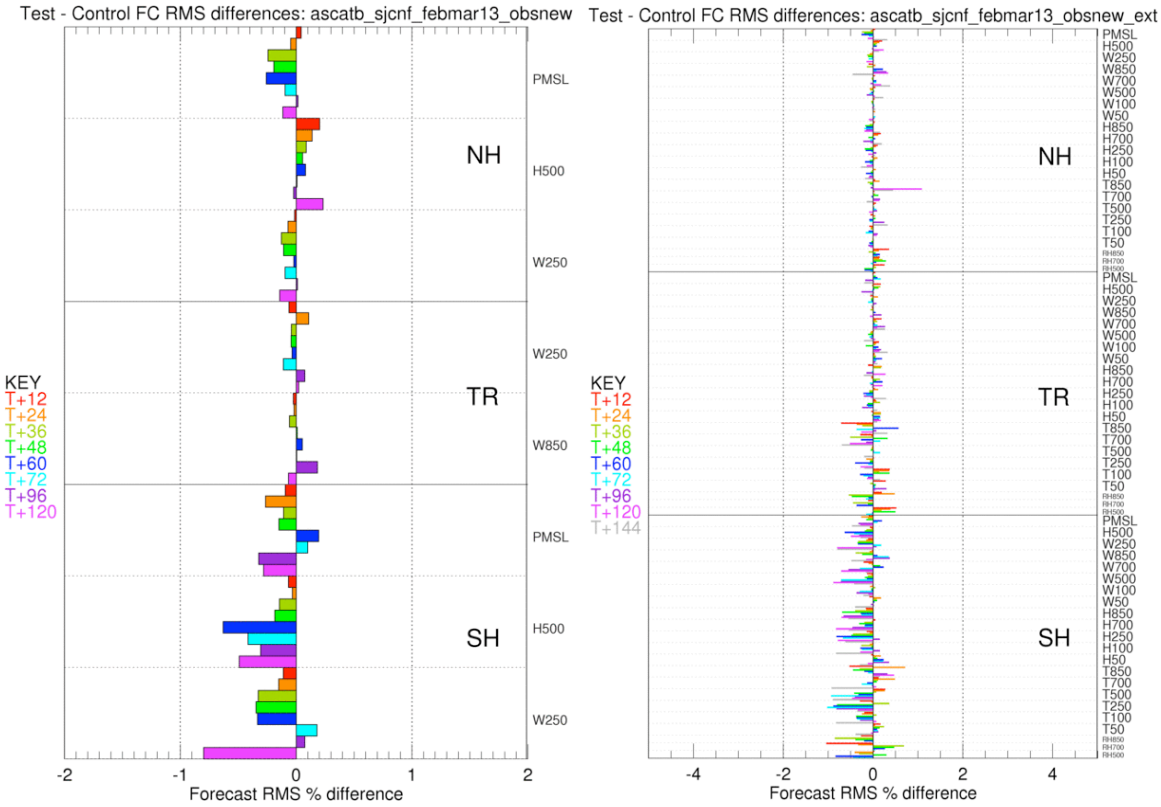

Figure 8. Percentage change in forecast RMS error (forecast minus observations) between the trial with individual thinning (sjcnf) and the control experiment (sjcna). The colour of the bars represents the different forecast lead times and negative values indicate a reduction in forecast error. Main NWP index parameters (left) and the extended set of parameters (right).

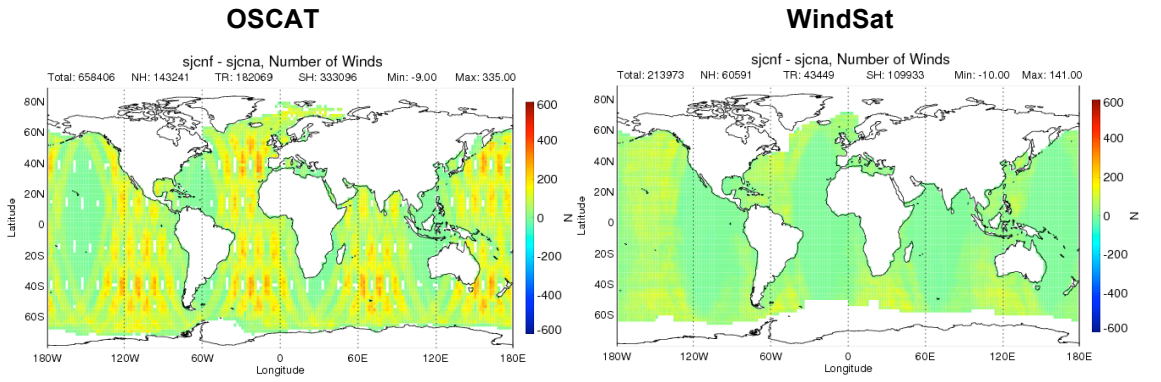

Figure 9. Map of differences in observation numbers between the trial sjcnf and the control sjcna: OSCAT (left) and WindSat (right).

b) ASCAT-B impact

Next we consider the impact of ASCAT-B data within the current operational thinning scheme (sjcnc vs sjcna) and with the new individual thinning scheme (sjcnd vs sjcnf).

The NWP index scores in Table 3 show that ASCAT-B has a similar magnitude of impact under both schemes, with both experiments demonstrating a neutral-to-small positive impact on forecast RMS error. The benefit to the NWP index from ASCAT-B is roughly half what we currently gain from ASCAT-A. The change in forecast RMS (trial – control) for the NWP index parameters is given in Figure 10. Both ASCAT-B experiments show a small benefit on PMSL and 500 hPa geopotential height in the northern hemisphere and a neutral impact in the tropics. There are small benefits in the southern hemisphere e.g. 500 hPa geopotential height for the operational thinning trial, but these are slightly less consistent. For the individual thinning trial there is a small degradation in 250 hPa winds at T+120.

For the individual thinning scheme, Figure 11 shows that changes in forecast error of PMSL at T+48 occur mainly in the mid-high latitudes. The North and South Atlantic in particular show a fairly consistent positive impact from ASCAT-B and the reductions in RMS generally occur where the errors are largest.

If we consider the extended set of forecast parameters (Figure 12) and not just those in the NWP index, then for both experiments we generally see:

- Small positive impact in the northern hemisphere, particularly on height scores and PMSL
- Little signal in the tropics
- Mixed signal in the southern hemisphere, but slightly better impact with operational thinning.

Looking at the southern hemisphere in more detail, using operational thinning we see improvements to height scores and to temperature scores (500/700 hPa) from T+72 out. However there is a small degradation for low level winds at 850 hPa. Using the individual thinning scheme, we still see benefits to height scores but the main difference is that we observe less benefit on temperature scores and in fact some degradation on temperatures at 500 hPa and 250 hPa.

The impact of ASCAT-B is similar in both thinning schemes, despite a large difference in the number of observations assimilated. For the operational thinning scheme, the number of ASCAT-B observations used is half that of ASCAT-A and only in areas not already observed by ASCAT-A. For the new individual thinning scheme, we are doubling the total number of used ASCAT observations but still only see a similar level of improvement. Taken together, these results could suggest that we only see benefit from ASCAT-B where we are adding observations into areas not already observed by ASCAT-A. However, the results of the individual thinning (only) trial showed a positive impact from adding OSCAT and WindSat observations in regions already observed by ASCAT-A. The explanation for the differing impact may lie in the temporal separation between instruments where they overlap. Figure 13 shows time difference histograms for ASCAT-A observations collocated with the nearest OSCAT and ASCAT-B observation. Spatial collocations were within 10 km and the only time constrain was that the observation had to be within the same assimilation cycle. For ASCAT-A and ASCAT-B we are observing the same patch of ocean only 50 mins apart, whereas for collocated ASCAT-A and OSCAT data the histogram shows a much wider range of time differences. OSCAT collocations have a bi-modal distribution with matchups frequently separated by around 100 mins and 150 mins. It may be that temporal separation of ASCAT-A and ASCAT-B is too small to provide substantial extra information to the analysis where they overlap. However, we would still expect to benefit from the noise reduction properties of assimilating two ASCAT observations rather than just one.

Overall, the combined impact of using the individual thinning scheme and adding ASCAT-B is +0.29 on the NWP index. This compares to +0.13 from adding ASCAT-B in the operational thinning scheme. The use of separate thinning rounds for all the instruments therefore does provide some benefit on the NWP index.

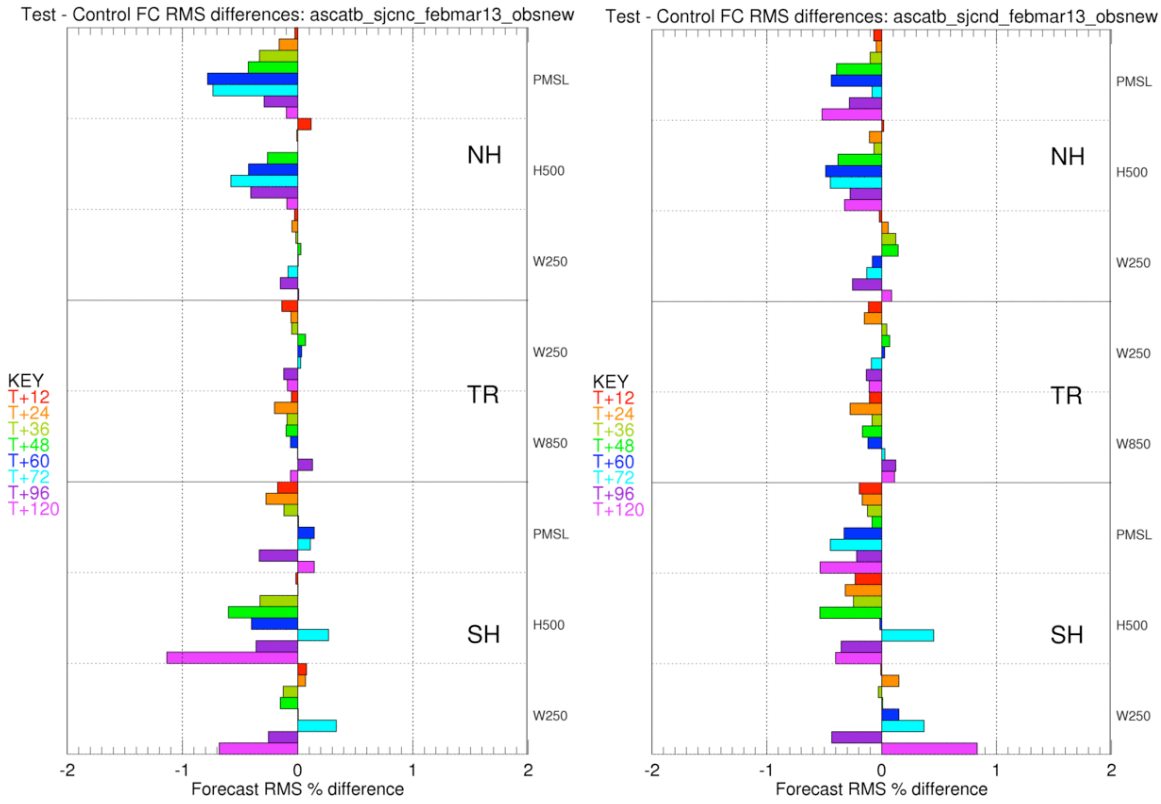

Figure 10. Impact on NWP index: percentage change in forecast RMS error (forecast minus observations) between the ASCAT-B trials and their respective control experiments. The impact of adding ASCAT-B with operational thinning (left) and individual thinning (right).

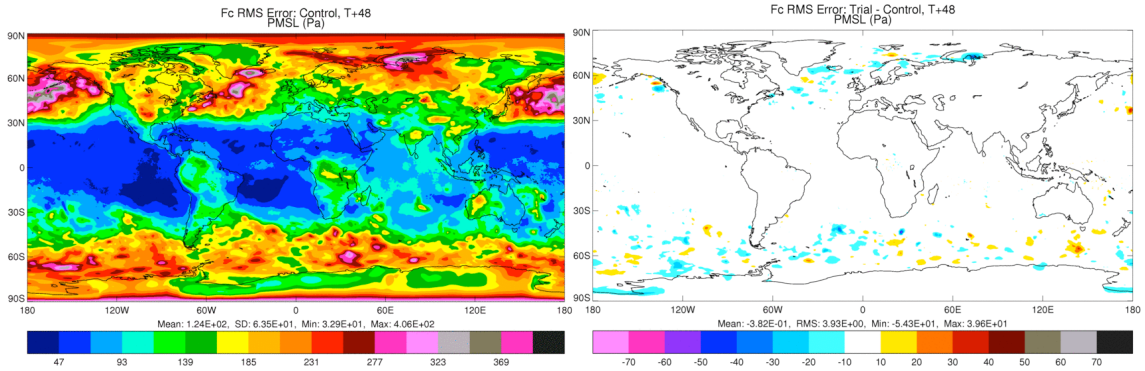

Figure 11. Maps of T+48 forecast error for PMSL: RMS error in the reference suite sjcnf (left) and the difference in RMS error between the ASCAT-B trial (sjcnd) and the reference (sjcnf). Negative values in the difference plot indicate a reduction in RMS error due to ASCAT-B. Forecasts verified against each experiments own analysis from 1 Feb 2013 to 23 March 2013

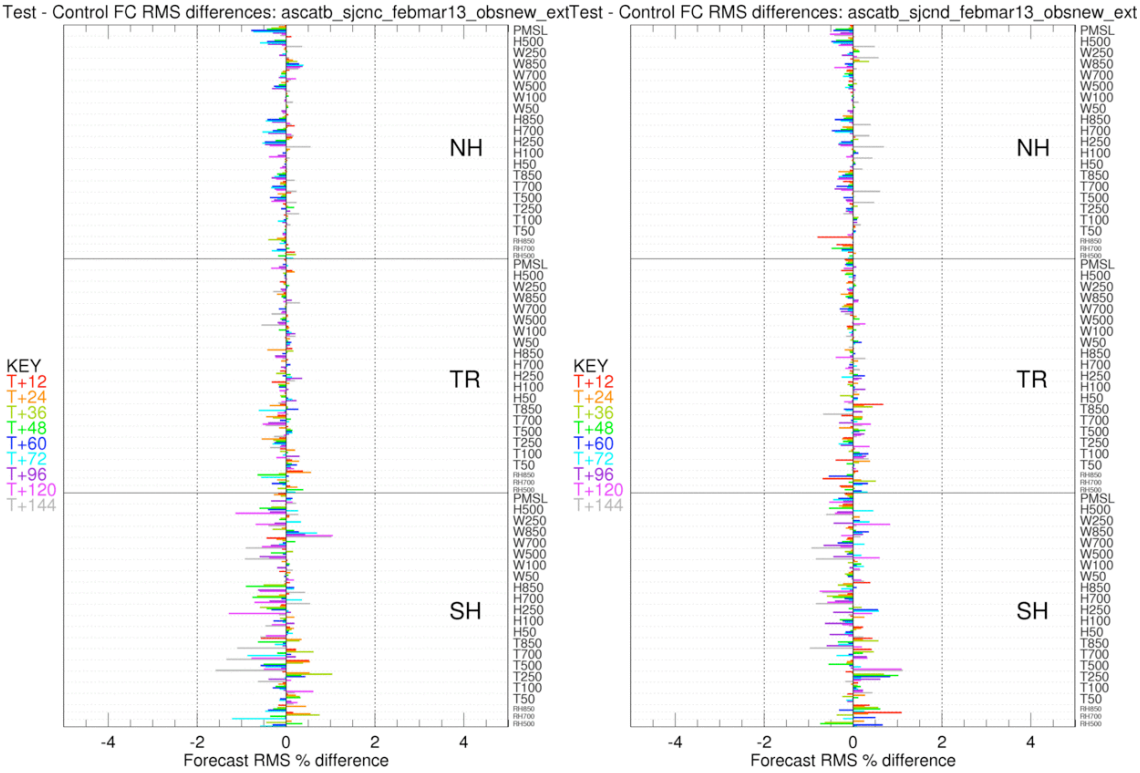

Figure 12. As Figure 10 but for the extended set of forecast parameters. The impact of adding ASCAT-B with operational thinning (left) and individual thinning (right).

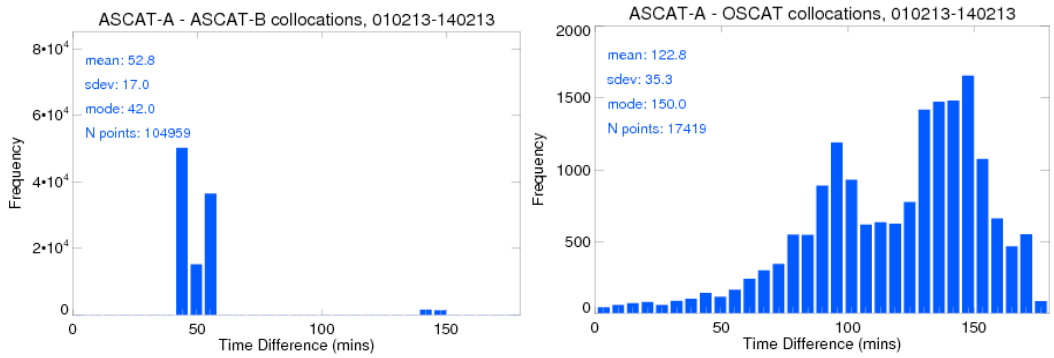

Figure 13. Histograms of the time difference (mins) between collocated ASCAT-A and ASCAT-B observations (left) and between ASCAT-A and OSCAT observations (right). Collocations were within 10km and within the same assimilation cycle. Data are those assimilated in trial sjcnd for the period 1-14 February 2013.

6.2 Impact of ASCAT-B on fit to background/analysis

As the impact on the NWP index is similar under both thinning schemes, we focus additional verification on the experiment using individual thinning. Comparing experiment sjcnd with reference sjcnf presents cleaner results as there are no changes in the use of other scatterometer observations: the only change is the addition of ASCAT-B.

The impact of assimilating ASCAT-B can further be diagnosed by comparing the change in fit of scatterometer and other observations to analyses and short range forecasts. Statistics output from 4D-Var show that the addition of ASCAT-B results in a 3% reduction in the RMS fit to analyses for the overall Scatwind u-component. The term Scatwind is used here to refer to all ocean surface wind observations from scatterometers and from WindSat. The Scatwind v-component fit to analysis is reduced by 2% and the fit to model background is reduced by 1% and 1.5% for u and v wind components respectively. Figure 14 shows the change in fit to model background for ASCAT-A, OSCAT and WindSat in terms of speed, direction, u and v components. All instruments show equal or reduced standard deviations with the addition of ASCAT-B. The largest difference is for ASCAT-A u component fit in the tropics (3% reduction).

With the addition of ASCAT-B, the mean number of scatterometer observations assimilated per cycle increases by 47% from around 26,000 to 38,000. Figure 15 shows that both the experiment including ASCAT-B (sjcnf) and its reference (sjcnd) suite experienced two noticeable drop-outs in observation numbers during the trial period. There was a large fall in observations for a couple of cycles after 18z on 20 March due to a planned out-of-plane manoeuvre for Metop-A, denying ASCAT-A data for these runs. From 2 March (cycle 116) to 6 March both trials experienced a loss of around 10,000 observations due to a satellite transmission problem on Oceansat-2 which denied the use of OSCAT data. Figure 15 shows that during the prolonged OSCAT outage, the RMS fit of the observations to the v-component analysis field increased by around 0.1m/s for the reference suite. The increase in RMS for the experiment with ASCAT-B data was much less and the time series shows that the gap between the trials grew much larger during this time. Over the whole trial, the RMS was reduced by around 2%, but during the OSCAT outage the reduction in RMS grew to around 7%. A similar impact was seen for the analysis u-component. Figure 16 shows that the benefit of ASCAT-B on the NWP Index was most consistent during the first week of March, coinciding with the absence of OSCAT. These results demonstrate that the addition of ASCAT-B has led to a more resilient assimilation system and that the benefit of a second ASCAT is greatest when we lose another important instrument such as OSCAT.

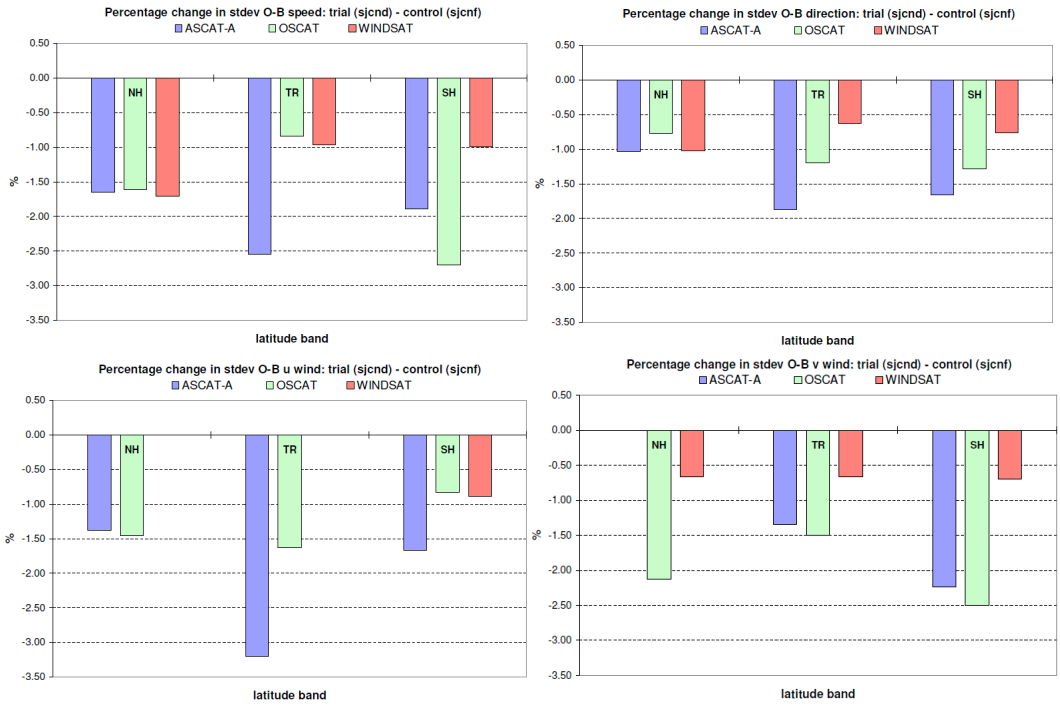

Figure 14. Percentage change in standard deviation fit to model background as a result of assimilating ASCAT-B: speed (top left), direction (top right), u component (bottom left) and v component (bottom right). ASCAT-A shown in blue, OSCAT in green and WindSat in red.

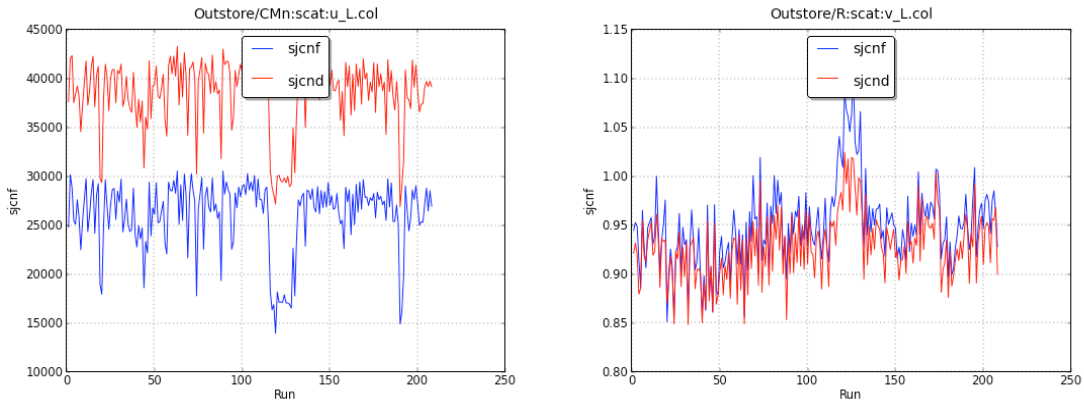

Figure 15. Time series plots comparing experiment sjcnf (add ASCAT-B) and reference suite sjcnd: the number of Scatwind observations assimilated (left) and the RMS fit of the v-component to the analysis (right). Dates are from 1 February 2013 (cycle 1) to 25 March 2013 (cycle 208).

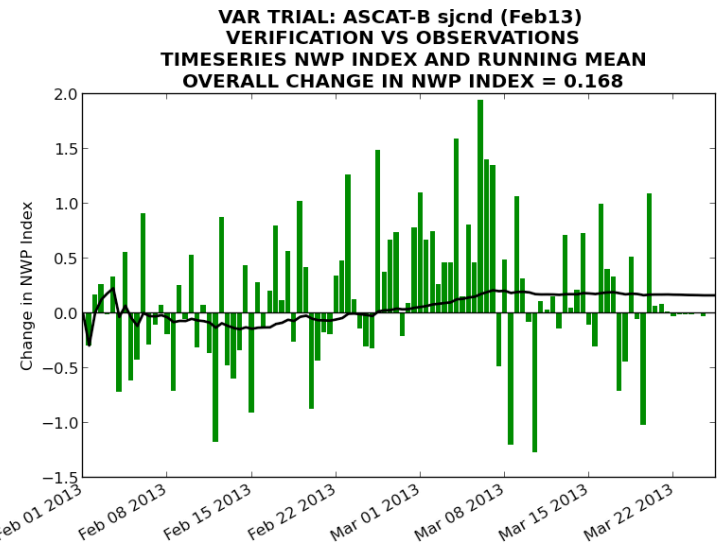

Figure 16. Change in NWP index for experiment sjcnd versus reference suite sjcnf for the period 1 February 2013 to 25 March 2013. Verification is against observations. The benefit of ASCAT-B can be seen during the OSCAT outage from 2-6 March 2013.

7 Conclusions

Ocean surface wind vectors from ASCAT on Metop-B have been assimilated in the Met Office global model from 30 April 2013. The assimilation method and quality control follows that already used for ASCAT on Metop-A. Routine O-B monitoring results have shown that the quality of winds from ASCAT-B is very similar to that of ASCAT-A with only small differences in speed bias for observations above 15 m/s. Due to the orbital overlap with ASCAT-A the number of additional observations after thinning is fairly modest in the current assimilation scheme at around 15%.

To better exploit data from parallel ASCAT-A/B operations a new ‘individual’ scatterometer thinning scheme has been proposed. Under the current ‘operational’ thinning scheme all observations are thinned together and overall priority is given to ASCAT-A. Under the individual scheme there are separate spatial thinning rounds for each instrument and, with ASCAT-B in use, the total number of Scatwind observations increases by 50%. An assimilation trial was been performed during February and March 2013 to gauge the impact of the new thinning scheme, initially without ASCAT-B data. The impact on the Met Office global NWP Index was found to be neutral-to-slightly positive (+0.12) when verified against observations. Improvements in forecast error were generally seen in the southern hemisphere for 500 hPa geopotential height and 250 hPa winds. The positive impact results from assimilating more OSCAT and WindSat observations in areas already observed ASCAT-A, with most data added in the southern hemisphere.

A further set of impact experiments were performed to investigate the impact of adding ASCAT-B winds in both the operational and individual thinning schemes. Both experiments demonstrated a neutral-to-small positive impact on forecast RMS error from the addition of ASCAT-B. Small improvements were seen on height scores and PMSL in the northern hemisphere but the signal in the southern hemisphere was slightly more mixed. No impact was observed in the tropics.

The overall impact of ASCAT-B is rather similar under both thinning schemes, despite a large difference in the number of observations assimilated. For the operational thinning scheme, the number of ASCAT-B observations used is half that of ASCAT-A, and only in areas not already observed by ASCAT-A. Here the benefit to the NWP index from ASCAT-B (+0.13) is roughly half what we currently gain from ASCAT-A (+0.22). For the new individual thinning scheme, although we are doubling the total number of used ASCAT observations used we still only see a similar level of improvement. This suggests that the main benefit from ASCAT-B occurs when we are adding observations into areas not already observed by ASCAT-A. The temporal separation of ASCAT-A and ASCAT-B at 50 mins may be too small to provide much extra information to the analysis where the swaths overlap.

The assimilation of ASCAT-B is found to improve the fit of ASCAT-A, OSCAT and WindSat to the analysis and background wind fields by up to 3%. Over the whole trial the u/v wind component fit to the analysis field was improved by around 2-3%, but during a period of several days without OSCAT data the improvement grew to around 7%. The largest benefit to the NWP index also coincided with the absence of OSCAT data. The results show that the addition of ASCAT-B leads to a more resilient system and that the benefit of a second ASCAT is greatest when we lose another important instrument such as OSCAT.

Overall, the use of separate thinning rounds for all the instruments has been shown to provide some benefit, primarily from the use of more OSCAT data in overlap regions. The new individual scatterometer thinning scheme is therefore recommended for further trialling in a second season (SH winter 2013) and possible implementation in a future operational suite upgrade

References

ASCAT Wind Product User Manual, Version 1.13, May 2013. OSI SAF. Document SAF/OSI/CDOP/KNMI/TEC/MA/126
http://www.knmi.nl/scatterometer/publications/pdf/ASCAT_Product_Manual.pdf

Candy, B. and S. J. Keogh, 2008. The Impact of MetOp-A ASCAT ocean surface wind vectors on Met Office Global Model Forecasts. Forecasting research technical report number 511.

Joo, S., Eyre, J. and R. Marriott, 2012. The impact of Metop and other satellite data within the Met Office global NWP system using an adjoint-based sensitivity method. Forecasting Research Technical Report no. 562, February 2012.

Acknowledgements

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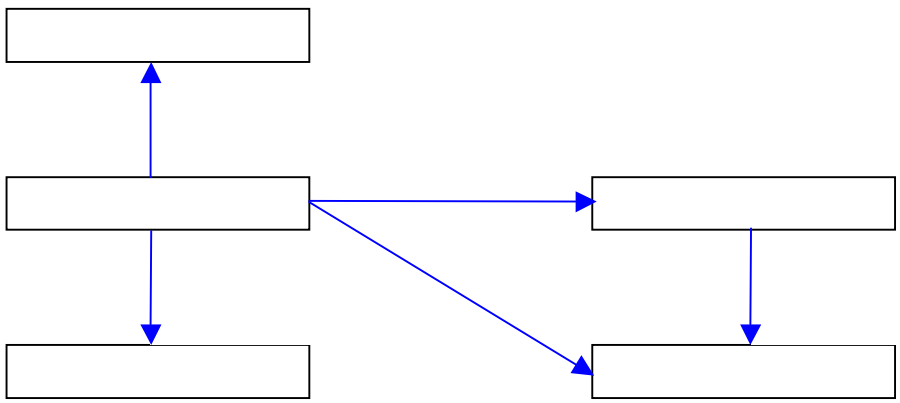
WindSat data are produced at the US Naval Research Laboratory.

Appendix

A schematic of the experiment configurations and the changes in the global NWP index are given below. Impacts follow the direction of the arrows.



Met Office
FitzRoy Road, Exeter
Devon EX1 3PB
United Kingdom

Tel: 0870 900 0100
Fax: 0870 900 5050
enquiries@metoffice.gov.uk
www.metoffice.gov.uk